Summary for Policymakers

Climate Change Futures

Health, Ecological and Economic Dimensions

A Project of:
The Center for Health and the Global Environment
Harvard Medical School

Sponsored by:
Swiss Re
United Nations Development Programme

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The full list of the Centre for Global Dialogue Executive Roundtable participants is appended to the final report, which is available at www.climatechangefutures.org.

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PREAMBLE

"Imagining the unmanageable" was to be the subtitle for the Climate Change Futures report. But the devastating series of intense, immense fall hurricanes besetting the United States displaced it. What were once extreme scenarios for the US have occurred, and the consequences have cascaded across the physical landscape, overwhelming the capacities of health, ecological and economic systems to absorb, adapt to and manage the change.

Hurricane Katrina killed over 1,000 people, displaced over a million people, and spread oil, toxins, microorganisms and deep losses throughout the US Gulf Coast. It revealed deep-seated inequities and vulnerabilities, and the shock waves have reverberated through all sectors of society. The need for prevention has become embedded into our future political landscape.

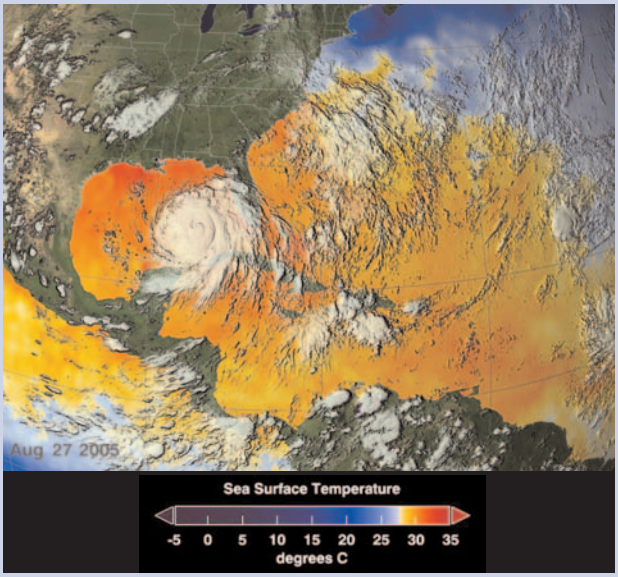
While no one event is diagnostic of climate change, the relentless pace of unusually severe weather since 2001 — prolonged droughts, heat waves of extraordinary intensity, violent windstorms and more frequent "100-year" floods — is descriptive of a changing climate.

The reasons for the changed weather patterns are well understood. Five years ago, Levitus and colleagues at the US Department of Commerce's National Oceanic and Atmospheric Administration reported that the world's oceans had warmed to a depth of two miles in five decades. This year Barnett and colleagues at the Scripps Institution of Oceanography reported that the oceans had absorbed 84% of the globe's warming and that the warming pattern is unmistakably attributable to human activities.

Because of the natural cycles on which global warming is superimposed, the overall frequency of hurricanes ebbs and flows. But, since the 1970s, tropical storm destructiveness (peak winds and duration) (Emanuel 2005) and the frequency of category 4 and 5 storms (Webster et al. 2005) have essentially doubled. These observations are correlated with warming tropical seas, and the scientists project that continued warming will likely enhance the frequency of large storms still further.

Warm sea surfaces evaporate quickly and, with the deep ocean warming, the water replenishing that which evaporates is also warm and fuels subsequent storms. A warmer atmosphere also holds more water vapor, and the accelerated water cycle generates more droughts and more floods (Trenberth 2005).

Hurricane Katrina



Warm ocean waters fuel hurricanes. This image depicts the three-day average of sea surface temperatures (SSTs) from August 25-27, 2005, and the growing breadth of Hurricane Katrina as it passed over the warm Gulf of Mexico. Yellow, orange and red areas are at or above 82°F (27.7°C), the temperature needed for hurricanes to strengthen. By late August SSTs in the Gulf were well over 90°F (32.2°C). Source: NASA/Goddard Space Flight Center/Scientific Visualization Studio

This fall's succession of megastorms is, at the very least, a harbinger of what we can expect more of in a changing climate (Kerr 2005). The series may also mark a turning point in our understanding of how an energized climate system is exaggerating natural phenomena and of just how rapidly climate has changed.

This multidimensional assessment of climate change includes trends, case studies and scenarios — with a focus on health, ecological and economic dimensions. One surprise is the vulnerability of the energy sector — the primary source of increased heat in Earth systems. The risks to oil production compound the threats to the electricity grid from heat waves and the instabilities of pipelines grounded in thawing tundra.

At the same time, recovery, adaptation and prevention open the door to enormous opportunities. Developing a diversified portfolio of safe, well-distributed and non-polluting energy sources, with hybrids and complementing technologies, can fortify energy security, bolster public health, promote economic activity and help stabilize the climate. Bold initiatives and innovative measures spearheading a well-funded, well-insured clean energy transition may be just the components needed to build a sustainable engine of growth for the 21st century.

– Paul Epstein and Evan Mills

EXECUTIVE SUMMARY

Climate is the context for life on earth. Global climate change and the ripples of that change will affect every aspect of life, from municipal budgets for snowplowing to the spread of disease. Climate is already changing, and quite rapidly. With rare unanimity, the scientific community warns of more abrupt and greater change in the future.

Many in the business community have begun to understand the risks that lie ahead. Insurers and reinsurers find themselves on the front lines of this challenge since the very viability of their industry rests on the proper appreciation of risk. In the case of climate, however, the bewildering complexity of the changes and feedbacks set in motion by a changing climate defy a narrow focus on sectors. For example, the effects of hurricanes can extend far beyond coastal properties to the heartland through their impact on offshore drilling and oil prices. Imagining the cascade of effects of climate change calls for a new approach to assessing risk.

The worst-case scenarios would portray events so disruptive to human enterprise as to be meaningless if viewed in simple economic terms. On the other hand, some scenarios are far more positive (depending on how society reacts to the threat of change). In addition to examining current trends in events and costs, and exploring case studies of some of the crucial health problems facing society and the natural systems around us, "Climate Change Futures: Health, Ecological and Economic Dimensions" uses scenarios to organize the vast, fluid possibilities of a planetary-scale threat in a manner intended to be useful to policymakers, business leaders and individuals.

Most discussions of climate impacts and scenarios stay close to the natural sciences, with scant notice of the potential economic consequences. In addition, the technical literature often "stovepipes" issues, zeroing in on specific types of events in isolation from the real-world mosaic of interrelated vulnerabilities, events and impacts. The impacts of climate change cross national borders and disciplinary lines, and can cascade through many sectors. For this reason we all have a stake in adapting to and slowing the rate of climate change. Thus, sound policymaking demands the attention and commitment of all.

While stipulating the ubiquity of the threat of climate change, understanding the problem still requires a lens through which the problem might be approached. "Climate Change Futures" focuses on health. The underlying premise of this report is that climate change will affect the health of humans as well as the ecosystems and species on which we depend, and that these health impacts will have economic consequences. The insurance industry will be at the center of this nexus, both absorbing risk and, through its pricing and recommendations, helping business and society adapt to and reduce these new risks. Our hope is that Climate Change Futures (CCF) will not only help businesses avoid risks, but also identify opportunities and solutions. An integrated assessment of how climate change is now adversely affecting and will continue to affect health and economies can help mobilize the attention of ordinary citizens around the world and help generate the development of climate-friendly products, projects and policies. With early action and innovative policies, business can enhance the world's ability to adapt to change and help restabilize the climate.

WHY SCENARIOS?

CCF is not the first report on climate change to use scenarios. The Intergovernmental Panel on Climate Change (IPCC) employs six of the very long-term and very broad scenarios representative of the many scenarios considered. Other organizations have explored scenarios of climate trajectories, impacts for some sectors and the mix of energy sources, to explore the potential consequences of trends and actions taken today. Scenarios are not simple projections, but are stories that present alternative images of how the future might unfold. Handled carefully, scenarios can help explore potential consequences of the interplay of multiple variables and thereby help us to make considered and comprehensive decisions.

The IPCC scenarios, contained in The Special Report on Emissions Scenarios (SRES), make projections into the next century and beyond and assume that climate change will be linear and involve gradual warming. But events of the last five years have overtaken the initial SRES scenarios. Climate has changed faster and more unpredictably than the scenarios outlined. Many of the phenomena assumed to lie decades in the future are already well underway. This faster pace of change on many fronts indicates that more sector-specific, short-term scenarios are needed.

With this in mind, the CCF scenarios are designed to complement the far-reaching IPCC framework. Drawing upon the full-blown, long-term scenarios offered by the IPCC, we have developed two scenarios that highlight possibilities inadequately considered in past assessments of climate change impacts.

Both CCF scenarios envision a climate context of gradual warming with growing variability and more weather extremes. Both scenarios are based on "business-as-usual," which, if unabated, would lead to doubling of atmospheric CO_2 from pre-industrial values by mid-century. Both are based on the current climate trends for steady warming along with an increase in extremes, with greater and costlier impacts. The compilation of extreme weather events of all types shows a clear increase over the past decade in the number of extremes occurring in both hemispheres (see figure below).

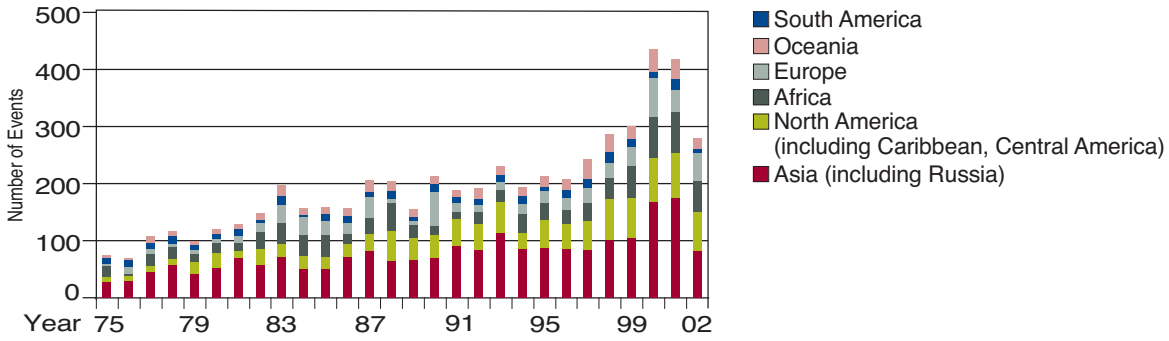
Overall costs from catastrophic weather-related events rose from an average of US $4 billion per year during the 1950s, to US $46 billion per year in the 1990s, and almost double that in 2004. In 2004, the combined weather-related losses from catastrophic and small events were US $107 billion, setting a new record. (Total losses in 2004, including non-weather-related losses, were US $123 billion; Swiss Re 2005a). With Hurricanes Katrina and Rita, 2005 had, by September, broken all-time records yet again. Meanwhile, the insured percentage of catastrophic losses nearly tripled from 11% in the 1960s to 26% in the 1990s and reached 42% (US $44.6 billion) in 2004 (all values inflation-corrected to 2004 dollars, Munich Re NatCatSERVICE).

As an insurer of last resort, the US Federal Emergency Management Agency has experienced escalating costs for natural disasters since 1990. Moreover, in

KEY POINTS

1. Warming favors the spread of disease.
2. Extreme weather events create conditions conducive to disease outbreaks.
3. Climate change and infectious disease threaten wildlife, livestock, agriculture, forests and marine life, which provide us with essential resources and constitute our life-support systems.
4. Climate instability and the spread of disease are not good for business.
5. The impacts of climate change could increase incrementally over decades.
6. Some impacts of warming and greater weather volatility could occur suddenly and become widespread.
7. Coastal human communities, coral reefs and forests are particularly vulnerable to warming and disease, especially as the return time between extremes shortens.
8. A more positive scenario is that climate reaches a new equilibrium, allowing a measure of adaptation and the opportunity to rapidly reduce the global environmental influence of human activities, namely fossil fuel combustion and deforestation.
9. A well-funded, well-insured program to develop and distribute a diverse suite of means to generate energy cleanly, efficiently and safely offers enormous business opportunities and may present the most secure means of restabilizing the climate.
10. Solutions to the emerging energy crisis must be thoroughly scrutinized as to their life cycle impacts on health and safety, environmental integrity, global security, and the international economy.

Extreme Weather Events by Region



These data are taken from EMDAT (Emergency Events Database) from 1975 to 2002. Compiled by the Center for Research on the Epidemiology of Disasters (CRED) at the Universite-Catholique de Louvain in Brussels, Belgium, this data set draws from multiple disaster relief organizations (such as OFDA and USAID), and is therefore skewed toward events that have large human impacts. The data taken from EMDAT were created with the initial support of WHO and the Belgian government.

the past decade, an increasing proportion of extreme weather events have been occurring in developed nations (Europe, Japan and the US) (see chart on page 6).

The first impact scenario, or CCF-I, portrays a world with an increased correlation and geographical simultaneity of extreme events, generating an overwhelming strain for some stakeholders. CCF-I envisions a growing frequency and intensity of weather extremes accompanied by disease outbreaks and infestations that harm humans, wildlife, forests, crops and coastal marine systems. The events and their aftermaths would strain coping capacities in developing and developed nations and threaten resources and industries, such as timber, tourism, travel and the energy sector. The ripples from the damage to the energy sector would be felt throughout the economy.

In CCF-I, an accelerated water cycle and retreat of most glaciers undermine water supplies in some regions and land integrity in others. Melting of permafrost (permanently frozen land) in the Arctic becomes more pronounced, threatening native peoples and northern ecosystems. And gradually rising seas, compounded by more destructive storms cascading over deteriorating barrier reefs, threaten all low-lying regions.

Taken in aggregate, these and other effects of a warming and more variable climate could threaten economies worldwide. In CCF-I, some parts of the developed world may be capable of responding to the disruptions, but the events would be particularly punishing for developing countries. For the world over, historical weather patterns would diminish in value as guides to forecasting the future.

The second impact scenario, CCF-II, envisions a world in which the warming and enhanced variability produce surprisingly destructive consequences. It explores a future rife with the potential for sudden, wide-scale health, environmental and economic impacts as climate change pushes ecosystems past tipping points. As such, it is a future inherently more chaotic and unpredictable than CCF-I.

Some of the impacts envisioned by the second scenario are very severe and would involve catastrophic, widespread damages, with a world economy beset by increased costs and chronic, unmanageable risks. Climate-related disruptions would no longer be contained or confined.

Threshold-crossing events in both terrestrial and marine systems would severely compromise resources and ecological functions, with multiple consequences for the species that depend upon them. For example:

- Repeated heat waves on the order of the 2003 and 2005 summers could severely harm populations, kill livestock, wilt crops, melt glaciers and spread wildfires.
- The probability of such extreme heat has already increased between two and four times over the past century and, based on an IPCC climate scenario, more than half the years by the 2040s will have summers warmer than that of 2003.
- Chronic water shortages would become more prevalent, especially in semi-arid regions, such as the US West.
- With current usage levels, more environmentally displaced persons and a changing water cycle, the number of people suffering water stress and scarcity today will triple in two decades.

VULNERABILITIES IN THE ENERGY SECTOR

Image: Photodisc

- Heat waves generate blackouts.
- Sequential storms disrupt offshore oil rigs, pipelines, refineries and distribution systems.
- Diminished river flows reduce hydroelectric capacity and impede barge transport.
- Melting tundra undermines pipelines and power transmission lines.
- Warmed inland waters shut down power plant cooling systems.
- Lightning claims rise with warming.

Each stage in the life cycle of oil, including exploration, extraction, transport, refining and combustion, carries hazards for human health and the environment. More intense storms, thawing permafrost and dried riverbeds, make every stage more precarious.

Other non-linear impact scenarios include:

- Widespread diebacks of temperate and northern forests from drought and pests.
- Coral reefs, already multiply stressed, collapse from the effects of warming and diseases.
- Large spikes occur in property damages from a rise of major rivers. (A 10% increase in flood peak would produce 100 times the damage of previous floods, as waters breach dams and levees.)
- Severe storms and extreme events occurring sequentially and concurrently across the globe overwhelm the adaptive capacities of even developed nations; large areas and sectors become uninsurable; major investments collapse; and markets crash.

CCF-II would involve blows to the world economy sufficiently severe to cripple the resilience that enables affluent countries to respond to catastrophes. In effect, parts of developed countries would experience developing nation conditions for prolonged periods as a result of natural catastrophes and increasing vulnerability due to the abbreviated return times of extreme events.

Still, CCF-II is not a worst-case scenario.

A worst-case scenario would include large-scale, non-linear disruptions in the climate system itself — slippage of ice sheets from Antarctica or Greenland, raising sea levels inches to feet; accelerated thawing of permafrost, with release of large quantities of methane; and shifts in ocean thermohaline circulation (the stabilizing ocean "conveyor belt").

Finally, there are scenarios of climate stabilization. Restabilizing the climate will depend on the global-scale implementation of measures to reduce greenhouse gas emissions. Aggressively embarking on the path of non-fossil fuel energy systems will take planning and substantive financial incentives — not merely a handful of temporizing, corrective measures.

This assessment examines signs and symptoms suggesting growing climate instability and explores some of the expanding opportunities presented by this historic challenge.

APPLYING THE SCENARIOS

In choosing how to apply the two impact scenarios, we have focused on case studies of specific health and ecological consequences that extend beyond the more widely studied issue of property damages stemming from warming and natural catastrophes. In each case study, we identify current trends under way and envision the future consequences for economies, social stability and public health.

Infectious diseases have resurged in humans and in many other species in the past three decades. Many factors, including land-use changes and growing poverty, have contributed to the increase. Our examination of malaria, West Nile virus and Lyme disease explores the role of warming and weather extremes in expanding the range and intensity of these diseases and both linear and non-linear projections for humans and wildlife.

The rising rate of asthma (two to threefold increase in the past two decades; fourfold in the US) receives special attention, as air quality is affected by many aspects of a changing climate (wildfires, transported dust and heat waves), and by the inexorable rise of atmospheric CO_2 in and of itself, which boosts ragweed pollen and some soil molds.

We also examine the public health consequences of natural catastrophes themselves, including heat waves and floods. An integrated approach exploring linkages is particularly useful in these instances, since the stovepipe perspective tends to play down the very real health consequences and the manifold social and economic ripples stemming from catastrophic events.

Another broad approach of the CCF scenarios is to study climate change impacts on ecological systems, both managed and natural. We examine projections for agricultural productivity that, to date, largely omit the potentially devastating effects of more weather extremes and the spread of pests and pathogens. Crop losses from pests, pathogens and weeds could rise from the current 42% to 50% within the coming decade.

THE CASE STUDIES IN BRIEF

Infectious and Respiratory Diseases

Malaria is the deadliest, most disabling and most economically damaging mosquito-borne disease worldwide. Warming affects its range, and extreme weather events can precipitate large outbreaks. This study documents the fivefold increase in illness following a six-week flood in Mozambique, explores the surprising role of drought in northeast Brazil, and projects changes for malaria in the highlands of Zimbabwe.

3,000 African children die each day from malaria.
Image: Pierre Virot/WHO

West Nile virus (WNV) is an urban-based, mosquito-borne infection, afflicting humans, horses and more than 138 species of birds. Present in the US, Europe, the Middle East and Africa, warm winters and spring droughts play roles in amplifying this disease. To date, there have been over 17,000 human cases and over 650 deaths from WNV in North America.

Culex pipiens mosquitoes breed in city drains.
Image: Biopix.dk

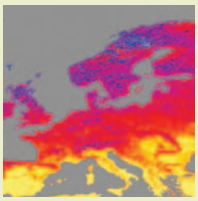
Lyme disease is the most widespread vector-borne disease in the US and can cause long-term disability. Lyme disease is spreading in North America and Europe as winters warm, and models project that warming will continue to shift the suitable range for the deer ticks that carry this infection.

The deer tick that carries Lyme disease.
Image: Scott Bauer/USDA Agricultural Research Service

Asthma prevalence has quadrupled in the US since 1980, and this condition is increasing in developed and underdeveloped nations. New drivers include rising CO_2, which increases the allergenic plant pollens and some soil fungi, and dust clouds containing particles and microbes coming from expanding deserts, compounding the effects of air pollutants and smog from the burning of fossil fuels.

Asthma rates have quadrupled in the US since 1980.
Image: Daniela Spyropoulou/Dreamstime

Extreme Weather Events



Heat waves are becoming more common and more intense throughout the world. This study explores the multiple impacts of the highly anomalous 2003 summer heat wave in Europe and the potential impact of such "outlier" events elsewhere for human health, forests, agricultural yields, mountain glaciers and utility grids.

Temperatures in 2003 were 6°C (11°F) above long-term summer averages.
Image: NASA/Earth Observatory

THE CASE STUDIES IN BRIEF

Floods inundated large parts of Central Europe in 2002 and had consequences for human health and infrastructure. Serious floods occurred again in Central Europe in 2005. The return times for such inundations are projected to decrease in developed and developing nations, and climate change is expected to result in more heavy rainfall events.

Floods have become more common in most continents.
Image: Bill Haber/AP

Natural and Managed Systems

Forests are experiencing numerous pest infestations. Warming increases the range, reproductive rates and activity of pests, such as spruce bark beetles, while drought makes trees more susceptible to the pests. This study examines the synergies of drought and pests, and the dangers of wildfire. Large-scale forest diebacks are possible, and they would have severe consequences for human health, property, wildlife, timber and Earth's carbon cycle.

Droughts and pest infestations contribute to the rise in forest fires.
Image: Dreamstime

Agriculture faces warming, more extremes and more diseases. More drought and flooding under the new climate, and accompanying outbreaks of crop pests and diseases, can affect yields, nutrition, food prices and political stability. Chemical measures to limit infestations are costly and unhealthy.

Healthy crops need adequate water and freedom from pests and disease.
Image: Ruta Saulyte/Dreamstime

Marine ecosystems are under increasing pressure from overfishing, excess wastes, loss of wetlands, and diseases of bivalves that normally filter and clean bays and estuaries. Even slightly elevated ocean temperatures can destroy the symbiotic relationship between algae and animal polyps that make up coral reefs, which buffer shores, harbor fish and contain organisms with powerful chemicals useful to medicine. Warming seas and diseases may cause coral reefs to collapse.

Coral reefs nourish fish and buffer shorelines.
Image: Oceana

Water, life's essential ingredient, faces enormous threats. Underground stores are being overdrawn and underfed. As weather patterns shift and mountain ice fields disappear, changes in water quality and availability will pose growth limitations on human settlements, agriculture and hydropower. Flooding can lead to water contamination with toxic chemicals and microbes, and natural disasters routinely damage water-delivery infrastructure.

Millions of people walk four hours per day to obtain clean water.
Image: Pierre Virot/WHO

THE INSURER'S OVERVIEW: A UNIQUE PERSPECTIVE

The concept of risk looms over all these impacts. Since the insurance industry provides a mechanism for spreading risk across time, over large geographical areas, and among industries, it provides a natural window into the broad macroeconomic effects of climate change.

The core business of insurance traditionally involves technical strategies for loss reduction as well as financial strategies for risk management and risk spreading. In both core businesses, as well as activities in financial services and asset management, the insurance sector is increasingly vulnerable to climate change. As such, insurers are impacted by and stand to be prime movers in responding to climate change. Insurers, states the Association of British Insurers, must be equipped to analyze the new risks that flow from climate change and help customers manage these risks. As real estate prices rise and more people inhabit vulnerable coasts and other at-risk areas, the number and intensity of weather-related disasters have also risen, and associated losses continue to rise despite substantial resources devoted to disaster preparedness and recovery.

The insurance perspective provides a useful access point for the Climate Change Futures project because of the macroeconomic role the insurance industry plays. Insurance is a major, time-tested method for adapting to change and any phenomenon that jeopardizes the ability of the global insurance industry to play this role will have a major disruptive effect. Moreover, instability is not good for business and unstable systems are prone to sudden change.

These major risks are an obvious concern for insurers and reinsurers, but they affect society as a whole. In the words of one prominent insurance executive, it's the clients who buy insurance who insure each other. The insurance industry provides the expertise and capacity to absorb and spread the risk, and reinsurers are vulnerable if those insurers that they insure are vulnerable.

POLICY MEASURES FOR EVERYONE

The Kyoto Treaty notwithstanding, and despite strong greenhouse gas reduction commitments by some governments, little action has been taken by most governments or businesses to address the potential costs of climate change. As all insurers know, however, risk does not compliantly bow to the political or business agenda. As the costs of inaction rise, the impetus for practical action by all stakeholders becomes all the more urgent. In the next several years, all nations will have energy, environmental and economic choices to make. No matter what scenarios are used, the initial focus should be on "no regrets" measures that will have beneficial consequences — and on formulating contingency plans that will work in different conceivable futures.

BUILDING AWARENESS

Understanding the risks and opportunities posed by climate change is the first step toward taking corrective measures. A broad educational program on the basic science and societal impacts of climate change is needed to better inform businesses, regulators, governments, international bodies and the public.

Regulators in every industry as well as governments need to use this knowledge to frame regulations in climate-friendly ways. Special attention is needed to identify misaligned incentives and identify throwbacks that come from earlier carbon-indifferent times.

Companies can study their own risks stemming from carbon dioxide emissions and incorporate their analyses into their strategy, planning and operations.

Insurers can amass more pertinent information and continue to improve climate risk assessment methods to overcome the lack of historical guidelines for assessing future climate. They can examine the new exposures, including liabilities. Climate change challenges all aspects of investments and insurance, and these risks must be better integrated into planning products, programs and portfolios.

Investors can evaluate their portfolios for climate risks and opportunities. Mainstream financial analyses can include climate issues in investment decisions. The capital markets can help educate clients about risks and strategies as well as the financial opportunities presented by new technologies.

All citizens can learn about their own "carbon footprint" and the implications of their own consumption and political participation.

THE CCF PROJECT IN BRIEF

The CCF project was developed from the concerns of three institutions, the Center for Health and the Global Environment at Harvard Medical School, Swiss Re and the United Nations Development Programme, regarding the rising risks that climate change presents for health, Earth systems and economies.

History

September 2003: Scoping Conference
United Nations Headquarters, New York City

June 2004: Executive Roundtable
Swiss Re Centre for Global Dialogue
Rüschlikon, Switzerland

August 2004: Workshop
Swiss Re
Armonk, NY

November 2005: Report Released
American Museum of Natural History, New York City

Unique Aspects of CCF

- The integration of corporate "stakeholders" directly in the assessment process.
- A combined focus on the physical, biological and economic impacts of climate change.
- Anticipation of near-term impacts, rather than century-scale projections.
- Inclusion of diseases of humans, other animals, land plants and marine life, with their implications for resources and nature's life-support systems.
- Involvement of experts from multiple fields: public health, veterinary medicine, agriculture, marine biology, forestry, ecology, economics and climatology and conservation biology.
- Scenarios of plausible futures with both gradual and step-wise change.
- Policy recommendations aimed at optimizing adaptation and mitigation.
- A framework for planning for climate-related surprises.

RAPIDLY REDUCING CARBON OUTPUT

Reducing the output of greenhouse gases on a global scale will require a concerted effort by all stakeholders and a set of integrated, coordinated policies. A framework for solutions is the following:

- Significant, financial incentives for businesses and consumers.
- Elimination of misaligned or "perverse" incentives that subsidize carbon-based fuels and environmentally destructive practices.
- A regulatory and institutional framework designed to promote sustainable use of resources and constrain the generation of wastes.

The critical issue is the order of magnitude of the response. The first phase of the Kyoto Protocol calls for a 6-7% reduction of greenhouse gas emissions below 1990 levels by 2012, while the IPCC calculates that a 60-70% reduction in emissions is needed to stabilize atmospheric concentrations of greenhouse gases. The size of the investment we make will depend on our understanding of the problem and on the pace of climate change.

The use of scenarios allows us to envision a future with impacts on multiple sectors and even climate shocks. "Imagining the unmanageable" can help guide constructive short-term measures that complement planning for the potential need for accelerated targets and timetables.

With an appreciation of the risks we face, actions to address the problem will become more palatable. Individuals and the institutions in which they are active can alter consumption patterns and political choices, which can influence accepted norms and markets. Corporate executive managers can declare their commitment to sustainability principles, such as those enunciated by Ceres[1] and the Carbon Disclosure Project[2], and those like the Equator Principles[3] to guide risk assessment, reporting practices and investment policies.

1. *Ceres is a national network of investments funds, environmental organizations and other public interest groups working to advance environmental stewardship on the part of business. http://www.ceres.org/*
2. *The Carbon Disclosure Project provides a secretariat for the world's largest institutional investor collaboration on the business implications of climate change. http://www.cdproject.net*
3. *The Equator Principles provide an industry approach for financial institutions in determining, assessing and managing environmental and social risk in project financing. http://www.equator-principles.com/principles.shtml*

Regulators and governments can employ financial instruments to create market signals that alter production and consumption. They can streamline subsidies so that climate-friendly investments of public and private funds are encouraged, and eliminate perverse incentives for oil and coal exploration and consumption. They can finance public programs using low-carbon technologies and formulate tax incentives that encourage consumers and producers to pursue climate-friendly activities. They can revise government procurement practices to stimulate demand, set up a regulatory framework for carbon trading and help construct the alternative energy infrastructure.

Industry and the financial sector, in partnership with governments and United Nations agencies, can establish a clean development fund to transfer new technologies, and finance and insure new manufacturing capability in developing nations. Insurers can influence the behavior of other businesses through revisions in coverage (easing the risk of adopting cleaner technologies), by developing their own expertise in low-carbon technologies and by working jointly with their clients to develop new products. Investors can find creative ways to incentivize the movement of investment capital toward renewable energy and away from polluting industries. Institutional investors, such as state and union pension funds, can play a pivotal role in this process. This can take the form of project finance or innovative financial instruments. The capital markets can foster the development of carbon risk-hedging products, such as derivatives, and promote secondary markets in carbon securities.

These measures would be sound even in the absence of climate change, as disaster losses will rise due to increased population and exposures alone. Similarly, efforts to reduce greenhouse gas emissions are typically cost-effective in their own right and bring multiple benefits, including reduced air pollution.

PLANNING AHEAD

Climate can change gradually, allowing some degree of adaptation. But even gradual change can be punctuated by surprises. Hurricane Katrina was of such breadth and magnitude as to overwhelm defenses, and could mark a turning point in the pace with which the world addresses climate change.

The compounding influences of vulnerabilities, along with the increasing destructiveness of moisture-laden storms, have been a tragic wake up call for all. As we embark on a publicly funded recovery program of enormous magnitude, the reconstruction process may itself set the global community on a course thought unlikely in the very recent past.

Planning on a global scale to restructure the development paradigm is not something societies have often done. At the end of World War II, following three decades of war, the dust bowl and depression, the Bretton Woods agreements established new monetary signals. Complemented by the Marshall Plan fund and the financial incentives embedded into the US GI bill, the combined "carrots and sticks" ushered in a productive post-war economic order.

The health, ecological and economic consequences of our dependence on fossil fuels are widespread and are becoming unsustainable. Will the triple crises of energy, the environment and ultimately the economy precipitate another "time out" in which all stakeholders come together to form the blueprints for a new financial architecture?

As we brace for more surprises we must prepare a set of reinforcing financial instruments that can rapidly jump-start a transition away from fossil fuels. The challenge of climate change presents grave risks and enormous opportunities, and the clean energy transition may be just the engine that takes us into a healthier, more productive, stable and sustainable future.

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The full CCF report is available at:
www.climatechangefutures.org.

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